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Published in:
Journal of Aging and Physical Activity

DOI:
10.1123/japa.2016-0357

Published: 01/04/2018

Document Version:
Peer reviewed version

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Abstract

Due to their high physical functioning, masters athletes are regularly proposed to exemplify successful aging. However, successful aging research on masters athletes has never been undertaken using a multidimensional successful aging model. To determine the best model for future successful aging research on masters athletes we had masters swimmers self-report (N = 169, M age = 57.4 years, 61% women) subjective successful aging, and physical, psychological, cognitive, and social functioning. Using this data we tested one hypothesized and three alternative successful aging models. The hypothesized model fit the data best (-2LL = 2052.32, AIC = 1717) with physical ($\beta = 0.31$, SE = 0.11), psychological ($\beta = 0.25$, SE = 0.11), and social ($\beta = 1.20$, SE = 0.63) functioning factors significantly loading onto a higher order successful aging latent factor. Successful aging should be conceptualized as a multidimensional phenomenon in future masters athlete research.

Keywords: Masters athletes, functioning, self-report

Testing a Model of Successful Aging in a Cohort of Masters Swimmers

Successful aging has been a central theme within gerontology for over half a century (Martin & Gillen, 2014). However, global population aging and its associated health, economic, and socio-structural challenges (Bloom, Canning, & Lubet, 2015) has raised academic interest in successful aging to new heights. Special editions of academic journals have been published (Pruchno, 2015; Rowe, 2015) and large scale research collaborations have been undertaken (Rowe & Kahn, 1997) to discuss and promote both individual and societal level successful aging. Moreover, successful aging research output is increasing at an unprecedented rate (Cosco & Kuh, 2016). Despite this research interest, there is currently no agreement on how to define successful aging (Cosco, Prina, Perales, Stephan, & Brayne, 2014b).

Successful Aging

The lack of a widely-accepted successful aging definition can be partially attributed to the fact that, until relatively recently, researchers did not invite older adults to help define or assess successful aging (Phelan, Anderson, Lacroix, & Larson, 2004; Strawbridge, Wallhagen, & Cohen, 2002). Moreover, *success* is a subjective term that gerontologists have historically used to formulate narrow and discipline-specific successful aging definitions (Bowling, 2007). Accordingly, successful aging has been broadly conceptualized by biomedical scientists as a state of physical and mental well-being at a particular time point in later life, or by psychosocial researchers as a process of lifespan adaptation to age-associated psychological, social, and life satisfaction change (Bowling, 2007). The use of different successful aging conceptualizations within research on older adults has resulted in highly varied successful aging prevalence rates (Cosco et al., 2014b).

The Vitality 90+ Study found that self-rated successful aging prevalence varied from 1.6% to 18.3% depending on which of six proposed successful aging models were applied (Nosraty, Sarkeala, Hervonen, & Jylhä, 2012). These findings parallel systematic review evidence which shows that 18 (Peel, Bartlett, & McClure, 2004), 29 (Depp & Jeste, 2006), and most recently 84 (Cosco, Prina, Perales, Stephan, & Brayne, 2014a) unique operational successful aging definitions have been used in successful aging research, generating prevalence rates ranging between 0.4% and 95%. These conceptual and prevalence disparities have hindered the generalizability of successful aging study findings, impeded cross-study comparisons, and prevented meta-analyses.

To overcome some of the limitations of previous successful aging research and encourage the use of more comprehensive and comparable successful aging conceptualizations in future research, gerontologists are urged to use the accumulated conceptual and empirical knowledge to develop a consensus on how to define successful aging (Pruchno, 2015). However, in light of the contentious past of successful aging discourse it may be unreasonable to expect a consensus (Pruchno, 2015). Rather, to improve the lives of older adults, it may be more reasonable to use a synthesis of perspectives to formulate testable and more acceptable successful aging definitions than have been previously used (Glass, 2003).

A synthesis of past successful aging operational definitions and older adult perspectives shows that successful aging can now be widely regarded as a multidimensional concept which embodies a state of high physical, psychological, cognitive, and social functioning (Bowling, 2007; Cosco et al., 2014b; Depp & Jeste, 2006; Peel et al., 2004; Phelan et al., 2004). Indeed, both original research (Cosco, Stephan, & Brayne, 2014; von Faber et al., 2001) and review material (Cheng, 2014; Geard et al., 2016) have provided a strong rationale for conceptualizing successful aging in this way. Therefore, in the present study, successful aging is conceptualized as high physical, psychological, cognitive, and social functioning.

Successful Aging and Masters Athletes

Non-modifiable factors such as chronological age, sex, and ethnicity influence successful aging. However, successful aging has also been associated with highly modifiable factors such as physical activity participation (Pruchno & Wilson-Genderson, 2014). Less sedentary (Dogra & Stathokostas, 2012), more physically active (Baker, Meisner, Logan, Kungl, & Weir, 2009), and physically fitter (Lin, Hsieh, Cheng, Tseng, & Su, 2016) community dwelling older adults tend to age more successfully across the various ways in which successful aging has been defined. Masters athletes regularly train for and compete in organized forms of individual or team sport specifically designed for older adults (Reaburn & Dascombe, 2008). As a result of their physical training and sports play, masters athletes are arguably the most physically active and fit older adult sub-cohort. Thus, masters athletes, particularly those who are endurance-trained, have been frequently proposed to exemplify successful aging (Cooper, Powell, & Rasch, 2007; Hawkins, Wiswell, & Marcell, 2003; Louis, Nosaka, & Brisswalter, 2012).

Endurance-trained masters athletes compete in long and short distance running, cycling, and swimming contests well into their 80's and 90's (Ransdell, Vener, & Huberty, 2009), and at levels that can surpass the most elite performances from the earliest Olympic Games (Tanaka & Seals, 2008). Moreover, they demonstrate significantly greater physiological capacities such as muscle strength and power (Wroblewski, Amati, Smiley, Goodpaster, & Wright, 2011) and maximum oxygen uptake (Trappe et al., 2013) than less active age-matched individuals. Endurance-trained masters athletes are clearly aging successfully in the physical domain. However, the research that proposes masters athletes as exemplars of successful aging has taken a parochial view of a heterogeneous masters athlete group and a more dimensional aging process.

Masters athletes may be novices or lifelong participants, recreationally or competitively involved, strength- or concurrently-trained, and individual or team players (Concannon, Grierson, & Harrast, 2012). Moreover, as previously mentioned, in addition to the physical domain, a synthesis of the literature suggests that successful aging is also a psychological, cognitive, and social phenomenon (Bowling, 2007; Cosco et al., 2014b). A recent review of the literature suggests that a broader range of masters athletes may exemplify successful aging across these domains (Geard, Reaburn, Rebar, & Dionigi, 2016). However, the validity of using a multidimensional successful aging model which incorporates these domains for research on masters athletes has not been tested.

The Present Study

The aim of the present study was to test a number of multidimensional successful aging models to determine which model is the most appropriate to use in future successful aging research on masters athletes. The tested models were formulated from a synthesis of the systematic review findings on researcher and older adult perspectives of successful aging (Bowling, 2007; Cosco et al., 2014b; Depp & Jeste, 2006; Peel et al., 2004). Cross-sectional data from a cohort of masters swimmers were analyzed to determine the fit of one hypothesized and three plausible alternative successful aging models. We predicted that the hypothesized model with successful aging as a higher order factor of high physical, psychological, cognitive, and social functioning would fit the data best.

Methods

Participants and Procedure

Masters swimmers responded to an online survey of self-rated successful aging, and physical, psychological, cognitive, and social functioning. Participants and non-competing attendees at the 2014 Australian National Masters Swimming Championships were invited to complete the survey using on-site laptop computers. Masters swimmers who attended the event but did not complete the survey, and masters swimmers who did not attend the event, were invited to complete the survey via email requests from Masters Swimming Australia. Data collection took place between April 23 and July 23, 2014. Informed consent was obtained by all respondents prior to commencing the survey. The study was approved by the researchers' institutional human research ethics committee (Project number H14/04-054).

Respondents ($N = 264$) were eligible for study inclusion if they: (a) provided informed consent (*n* excluded = 7, 2.7%), (b) self-identified as a masters athlete by responding *yes* to either of the following questions "*A masters athlete is someone who trains for, and competes in, organized forms of team or individual competitive sport specifically designed for adults of a particular age category. Do you identify as a masters athlete*?" or "*Did you compete in the 2014 National Master's Swimming Championships?*" (*n* excluded = 49, 18.6%), and (c) provided one or more survey responses beyond the informed consent and masters athlete questions (*n* excluded = 39, 14.8%). Therefore, 169 (21-85 years, *M* = 57.4, *SD* = 13.9) non-indigenous (100%), and predominantly Australian-born (*n* = 142, 84%), university educated (*n* = 128, 75.7%), professionally employed (*n* = 127, 75.1%), middle to high income earning (*n* = 125, 74% earned > $50,000 per year) female (*n* = 103, 60.9%) participants provided usable data.

Measures

The successful aging survey. The Veterans RAND 12 Item Health Survey (VR-12) was used to assess physical, psychological, and social functioning (Selim et al., 2009). The VR-12 is a valid and reliable survey developed from the Veterans RAND 36 Item Health Survey which was developed and modified from the original RAND version of the 36-item Health Survey version 1.0 (also known as the "MOS SF-36"). The Cognitive Failures Questionnaire was used as the basis for cognitive functioning assessment (Wallace, Kass, & Stanny, 2002). Self-rated successful aging was assessed using three questions from previous research (Pruchno & Wilson-Genderson, 2014).

Physical functioning. The two physical functioning items were: 'Does your health now limit you in everyday activities such as: (1) 'moving a table, pushing a vacuum cleaner, bowling, or playing golf?', and (2) 'climbing several flights of stairs?' The three response options were: *1 – yes, limited a lot, 2 – yes, limited a little*, and *3 – no, not limited at all*. The two role limitation items were: 'During the past four weeks, have you had any of the following with your work or other regular daily activities as a result of your physical health?': (1) 'accomplished less than you would like?', and (2) 'were limited in the kind of work or other activities?' The five response options were *1 – no, none of the time, 2 – yes, a little of the time*, *3 – yes, some of the time*, *4 – yes, most of the time,* and *5 – yes, all of the time*.

Psychological functioning. The two mental health items were: 'How much of the time during the past four weeks have you...' (1) 'felt calm and peaceful?', and (2) 'felt downhearted or blue?' The six response options were: *1 – all of the time, 2 – most of the time, 3 – a good bit of the time, 4 – some of the time, 5 – a little of the time,* and *6 – none of the time*. The two role limitation items were: 'During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)', (1) 'accomplished less than you would like?', and (2) 'didn't do work or other activities as carefully as usual?' The five response options were: *1 – no, none of the time, 2– yes, a little of the time, 3 – yes, some of the time, 4 – yes, most of the time,* and *5– yes, all of the time*.

Social functioning. The social functioning item was: 'During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?' The five response options were: 1 – all of the time, 2 – most of the time, 3 – some of the time, 4 – a little of the time, and 5 – none of the time.

Cognitive functioning. To best represent cognitive functioning and minimize participant burden, the items from the Cognitive Failures Questionnaire with the highest factor weightings from the memory, distractibility, blunders, and names subscales ($\alpha = 0.68$) were used. The items were: (1) 'Do you find you forget appointments?', (2) 'Do you read something and find you haven't been thinking about it and must read it again?', (3) 'Do you fail to hear people speaking to you when you are doing something else?' and, (4) 'Do you find you forget people's names?' with the response scale options: 0 – *never* to 4 – *always*.

Self-rated successful aging. Participants were asked to select a number that best represented: (1) how successfully they have aged (0 = *not successful at all* to 10 = *completely successful*), (2) how well they were aging (0 = *not well at all* to 10 = *extremely well*), and (3) how they would rate their life these days (0 = *the worst possible life* to 10 = *the best possible life*) (Pruchno & Wilson-Genderson, 2014).

Data Analyses

Multiple imputation by chained equations was used to account for missing data (Van Buuren & Groothuis-Oudshoorn, 2011). Structural Equation Modeling (Lei & Wu, 2007), model fit statistics, and *OpenMx* (Boker et al., 2011) in *R* version 3.1.1 (R Core Team, 2013) were used to determine which of the tested models best fit the data. Multiple imputation by chained equations avoids the deletion of costly collected and important data, and is a preferred method for imputing complex multivariate data because it specifies the multivariate imputation model on a variable-by-variable basis (Van Buuren & Groothuis-Oudshoorn, 2011). Structural equation modeling is a hypothesis testing approach which aims to determine if a hypothesized theoretical or conceptual model is consistent with the data collected. Model-data consistency, or the model fit, is evaluated using model fit statistics which indicate the plausibility of the postulated network of variable relationships (Lei & Wu, 2007). For each model, -2 log-likelihood (-2LL) and Akaike Information Criterion (AIC) were the model fit statistics calculated (Fox, Byrnes, Boker, Neale, 2012). A smaller -2LL and AIC represents a better fitting model; however, adding parameters will always improve model fit. Path values are shown in the best fitting model only and are represented by standard estimates (β) and standard errors (SE). *OpenMx* uses full-information likelihood estimation which is a robust modeling strategy, even with non-normal data (Enders & Bandalos, 2001).

<Insert Figure 1 here>

The hypothesized model (Figure 1) consisted of a higher order successful aging latent factor, three self-rated successful aging manifest variables (used to ensure the higher-order successful aging latent factor represented the concept of successful aging and not just overall wellbeing or some other positive late-life state), latent physical, psychological, and cognitive functioning factors, and a manifest social functioning variable (single item). The hypothesized models' fit was compared to the fit of three alternative models (Figure 2).

<Insert Figure 2 here>

Alternative model 1 (Figure 2a) was the same as the hypothesized model except that the psychological and cognitive functioning latent variables were combined. Alternative model 2 (Figure 2b) was the same as the hypothesized model except there was no psychological or cognitive functioning latent variables. Alternative model 3 (Figure 2c) was the same as the hypothesized model except there was no higher order successful aging latent variable and no psychological or cognitive functioning latent variables. All models were determined *a priori*. Prior to analysis, all raw data was transformed into Z-scores and assumptions were tested. No multivariate outliers were found. Latent factor variances were fixed at 1.0, but manifest variances were free to be estimated.

Results

A comparison of the various models tested (Table 1) revealed that the hypothesized model (Figure 1) fit the data better than any of the alternative models (Figure 2). The physical ($\beta = 0.31$, SE = 0.11) and psychological ($\beta = 0.25$, SE = 0.11) functioning latent factors, the social functioning manifest variable ($\beta = 1.20$, SE = 0.63), and the self-rated successful aging manifest variables (β's: 0.69 to 0.86) within the hypothesized model positively and statistically significantly loaded onto the higher order successful aging latent factor (all p's < .05). The latent cognitive functioning factor did not significantly load onto the higher order successful aging latent factor ($\beta = 1.08$, SE = 0.79). For simplicity, the estimated manifest variances are not depicted in Figure 1; they were all within expectations ($\sigma^2 = 0.27$ to 0.86).

<Insert Table 1 here>

Discussion

Four successful aging models were tested to determine the most appropriate for future successful aging research on masters athletes. As expected, the model fit statistic comparison tests showed that the hypothesized model in which successful aging was a higher order factor of physical, psychological, cognitive, and social functioning fit the data better than the alternative models. Moreover, the self-rated successful aging question responses indicated that the hypothesized model represented the masters swimmers' perceptions of successful aging. Many previously proposed successful aging models have been mostly or completely unidimensional (Bowling, 2007). In contrast, the present study's results are in line with an emerging field of research that emphasizes the multidimensionality of successful aging (Cho, Martin, & Poon, 2015; Doyle, Mc Kee, & Sherriff, 2012; Parslow, Lewis, & Nay, 2011; Vahia, Thompson, Depp, Allison, & Jeste, 2012). We found statistically significant relationships to justify the inclusion of physical, psychological, and social functioning domains in a successful aging operational model for future masters athlete research. However, the cognitive functioning domain was not significantly associated with successful aging.

The role of cognitive functioning in successful aging is yet to be resolved. Some successful aging model study's suggests cognitive functioning is important for successful aging (Cho et al., 2015; Parslow et al., 2011) while our findings support other research which indicates it is not (Vahia et al., 2012). However, we suspect that cognitive functioning is important for successful aging and did not significantly load onto the higher order successful aging latent factor because of a measurement issue arising from the limited number of cognitive functioning sub-domains measured, and/or the low internal consistency, self-rated nature, or low sensitivity of the cognitive functioning measures used. Before cognitive functioning is dismissed as an unimportant element of successful aging for masters athletes these potential sources of measurement artifact should be investigated. Conversely, before other factors are added to the present study's successful aging model they too should be investigated.

Subjective well-being (Cho et al., 2015), satisfaction with life (Parslow et al., 2011), and emotional functioning (Vahia et al., 2012) are among other constituent domains found in recently tested successful aging models. Although not part of this study's model, these domains were assessed using measures of affective status, as was the case with our psychological functioning domain. The similar measures used to assess these successful aging domains suggests that despite the different terminology a similar construct is being assessed, or that our psychological functioning domain is more dimensional than previously thought. Similarly, while not used in our model, predisposing factors such as education and physical activity have shown to predict successful aging in older individuals (Pruchno & Wilson-Genderson, 2014). These factors, among others, have therefore been incorporated into previous successful aging models (Cho et al., 2015; Parslow et al., 2011). However, researchers have often confused successful aging predictors with successful aging domains. For example, life satisfaction has been used interchangeably as a successful aging predictor, indicator, or domain (Cosco, 2015). Problems can arise when one type of factors is improperly utilized as another type to model successful aging (Cheng, 2014). An example of this is the low successful aging prevalence observed when researchers use the absence of disease as a successful aging domain rather than the predictor that it is (Montross et al., 2006; Strawbridge et al., 2002). Previous successful aging research has suggested that successful aging models clearly distinguish successful aging predictors and criteria (Bowling, 2007). Therefore, the present study elected to leave successful aging predictors out of the models that were tested. This approach allowed us to first determine the domains of successful aging before examining the various factors that may influence them.

Practice and Policy Implications

Previous successful aging research on the general older adult population indicates a longstanding discord regarding what successful aging is and how it should be measured (Cosco et al., 2014b; Depp & Jeste, 2006). This discord has yielded research findings that have been difficult to generalize, compare, and pool. The present study capitalizes on the extensive history of successful aging discourse by using a synthesis of successful aging conceptualizations to establish a multidimensional model for use in future successful aging research on a previously unexamined older adult sub-cohort; masters athletes. The use of this model, and extensions of it, will generate findings that can be generalized to the masters athlete subpopulation, compared to other studies, and eventually pooled in systematic reviews and meta-analyses.

As the present study's multidimensional model is operationalized in future observational and intervention research, findings will establish if sport holds health benefits above and beyond those conferred by generalized physical activity, which masters athlete and sport types are the most healthy, and what aspects of sport participation provide these health-enhancing properties. These findings could then be used to refute or substantiate claims that sport participation contributes to an increase in people's levels of health-enhancing physical activity (Eime et al., 2015), and provide an evidence base that informs medical and allied health professionals as to whether they should monitor (sport-related) physical activity as a fifth vital sign (Khan et al., 2012; Sallis et al., 2016). Successful aging investigations on masters athletes is clearly an important research direction for individual health. However, this research could also provide solutions to major societal issues associated with an aging global population.

The development of policy which facilitates sport-related successful aging could improve the future viability of nation's social welfare institutions. Unsustainable increases in governmental social welfare expenditure is a major concern for policy makers (Rowe, 2015) because more people living longer lives is projected to result in more age-related ill-health (Bloom et al., 2015). Interventions promoting sport-related successful aging may allow people to have healthier bodies and minds for longer, thereby reducing health care and social security reliance and spending. Moreover, sport-related successful aging could help older adults adapt to impending aged pension policy changes. In developed countries such as Australia, a significant proportion of older adults draw partial or full aged pensions for 20 or more years (Kulik, Ryan, Harper, & George, 2014). To make provision of the aged pension sustainable, such countries plan to increase the age at which people can access it. If this change occurs, successfully aging older individuals will be more able to financially absorb the extra period of time without a pension by engaging in paid work for longer (Zissimopoulos, Goldman, Olshansky, Rother, & Rowe, 2015). The present study's findings provide an empirical basis upon which to commence multidimensional successful aging research on masters athletes. A number of factors should be considered by those undertaking this research.

Considerations for Future Research

First, it has been historically difficult to determine which factors lead to successful aging and which represent it. Future research needs to continue disentangling the successful aging predictors from the outcomes with experimental and prospective study designs. Second, given that the present study was an initial model test, it is likely that some of the domains were not fully represented with the measures used. For example, social functioning was assessed using a single item in the present study. However, social functioning may be more than a single factor concept. Some evidence indicates that social functioning is assessable by quantifying the physical characteristics of a person's social network (Weissman, Olfson, Gameroff, Feder, & Fuentes, 2001), while loneliness research suggests that social functioning is also effected by a person's perception of their social network (Cacioppo, Fowler, & Christakis, 2009). Moreover, numerous other cognitive functioning indicators such as the ability to produce language and perform calculations exist (Cho et al., 2015; Parslow et al., 2011; Vahia et al., 2012). However, the present study only used items assessing concentration and memory. Third, the cross-sectional data analyzed for the present study provided a snapshot of the respondents' aging status. However, aging is a process (Hooyman & Kiyak, 2011). Therefore, interventions and longitudinal research are needed to investigate successful aging over time. Fourth, self-report measures were used in the present study to assess the successful aging domains. However, self-report data can be confounded by self-report and recall bias, or situational factors such as mood, fatigue, and recent experiences. Future research should supplement self-reported successful aging assessment with objective measurement techniques. Fifth, exceptional multidimensional functioning is a possibility in later life, however, using what is possible as the benchmark for successful aging can be problematic (Glass, 2003). Recent research has shown that when successful aging is assessed dichotomously via cutoffs representing high functioning very few people meet the required levels (Cosco et al., 2014). Therefore, successful aging assessment along a continuum rather than using dichotomous cutoffs might increase the social utility of successful aging research. Sixth, sport is a subset of physical activity (Khan et al., 2012). Successful aging research on masters athletes should therefore use study designs that allow researchers to detect the benefits derived from sport, those derived from generalized physical activity, and the factors that promote sport and physical activity-related successful aging. Finally, the present study analyzed data that was collected from a fairly homogeneous masters athlete cohort. All participants identified as masters swimmers, and the majority indicated they were middle-to-high income earning highly educated Caucasian females. It is likely that people with this sociodemographic profile are the most regular sports participants within the older adult population because their education, disposable income, and free time to train and travel facilitates this (Dionigi, 2016). Future research examining other types of masters athletes and more socio-demographically heterogeneous samples will help establish the generalizability of research findings.

Conclusion

Based on their high and sustained physical functioning, endurance-trained masters athletes are regularly proposed to exemplify successful aging (Cooper et al., 2007; Hawkins et al., 2003; Louis et al., 2012). However, successful aging is a multidimensional phenomenon (Cosco et al., 2014b). Although recently published literature suggests masters athletes exemplify a multidimensional conceptualization of successful aging (Geard et al., 2016), to date this hypothesis has not been empirically examined. To commence an examination of multidimensional successful aging in masters athletes we tested a number of successful aging models. We conclude that the model consisting of physical, psychological, and social functioning domains is the most valid to use in future research. Findings from this research will allow us to discover if sport participation can promote successful aging, and improve our understanding of the relationship between individual and societal level successful aging; which is proposed to be one of the greatest gerontological challenges of our time (Rowe & Kahn, 2015).

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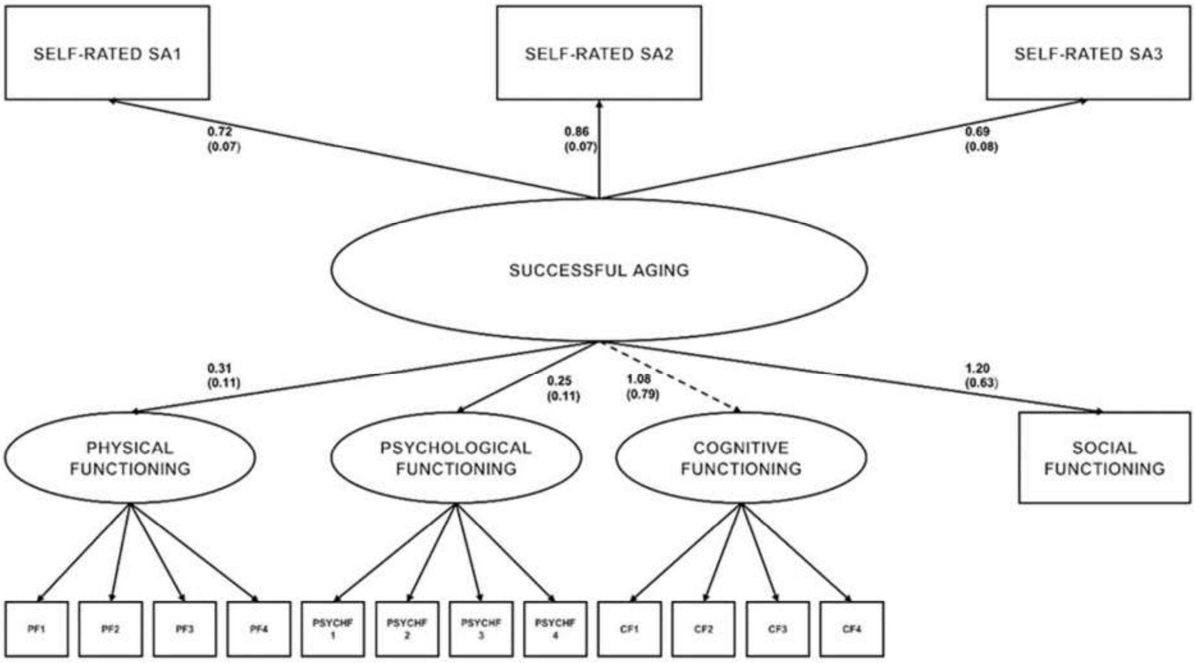

Figure 1. The hypothesized successful aging model where underlying successful aging is represented by physical, psychological, cognitive, and social functioning. Note: SA = successful aging; PF = physical functioning; PSYCHF = psychological functioning; CF = cognitive functioning. Oval shapes represent latent factors and rectangles or squares represent manifest factors. Path values are standard estimates with standard errors in parentheses. Solid path lines indicate statistically significant relationships ($p < .05$). Dashed path lines indicate statistically non-significant relationships.

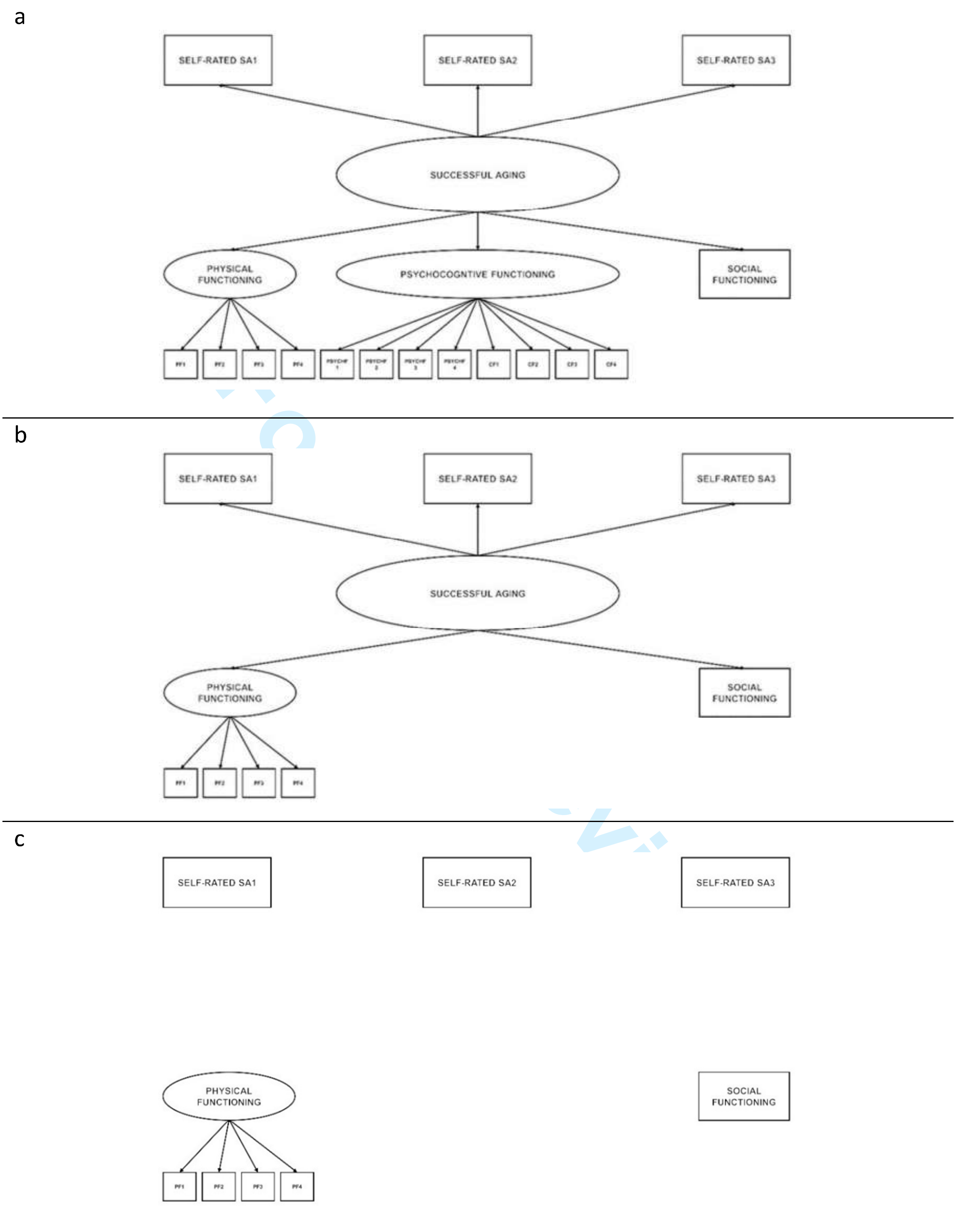

Figure 2. Alternative successful aging models. Note: SA = successful aging; PF = physical functioning; PSYCHF = psychological functioning; CF = cognitive functioning.

Table 1. Fit Statistic Comparison of the Hypothesized and Alternative Successful Aging Models

Model	-2LL	AIC
Hypothesized Model	2052.32	17.17
Alternative Model 1	2119.93	80.78
Alternative Model 2	2309.38	262.23
Alternative Model 3	2503.21	438.07

Note. -2LL = -2 Log-likelihood. AIC = Akaike Information Criterion.

[a] A smaller -2LL and AIC represents a better fitting model.